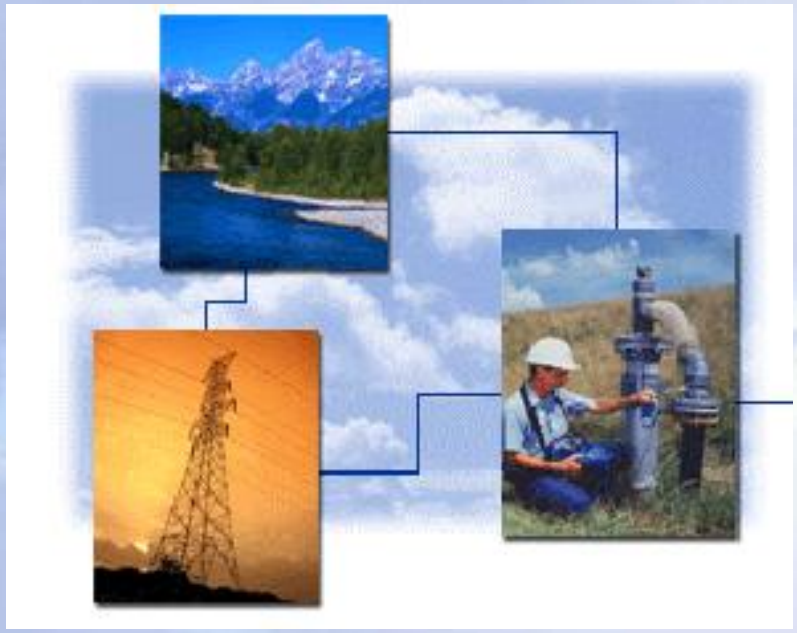
An Overview of Landfill Gas Energy in the United States



U.S. Environmental Protection Agency
Landfill Methane Outreach Program (LMOP)

File Last Updated: June 2008

Why EPA is Concerned about Landfill Gas

- Why is methane a greenhouse gas?
  - Methane absorbs terrestrial infrared radiation (heat) that would otherwise escape to space (GHG characteristic)
- Methane as GHG is over 20x more potent by weight than CO_2
- Methane is more abundant in the atmosphere now than anytime in the past 400,000 years and 150% higher than in the year 1750
- Landfills were the second largest human-made source of methane in the United States in 2006, accounting for 22.6% generated

EPA's Landfill Methane Outreach Program

- Established in 1994
- Voluntary program that creates alliances among states, energy users/providers, the landfill gas industry, and communities

Mission: To reduce methane emissions by lowering barriers and promoting the development of cost-effective and environmentally beneficial landfill gas energy (LFGE) projects.

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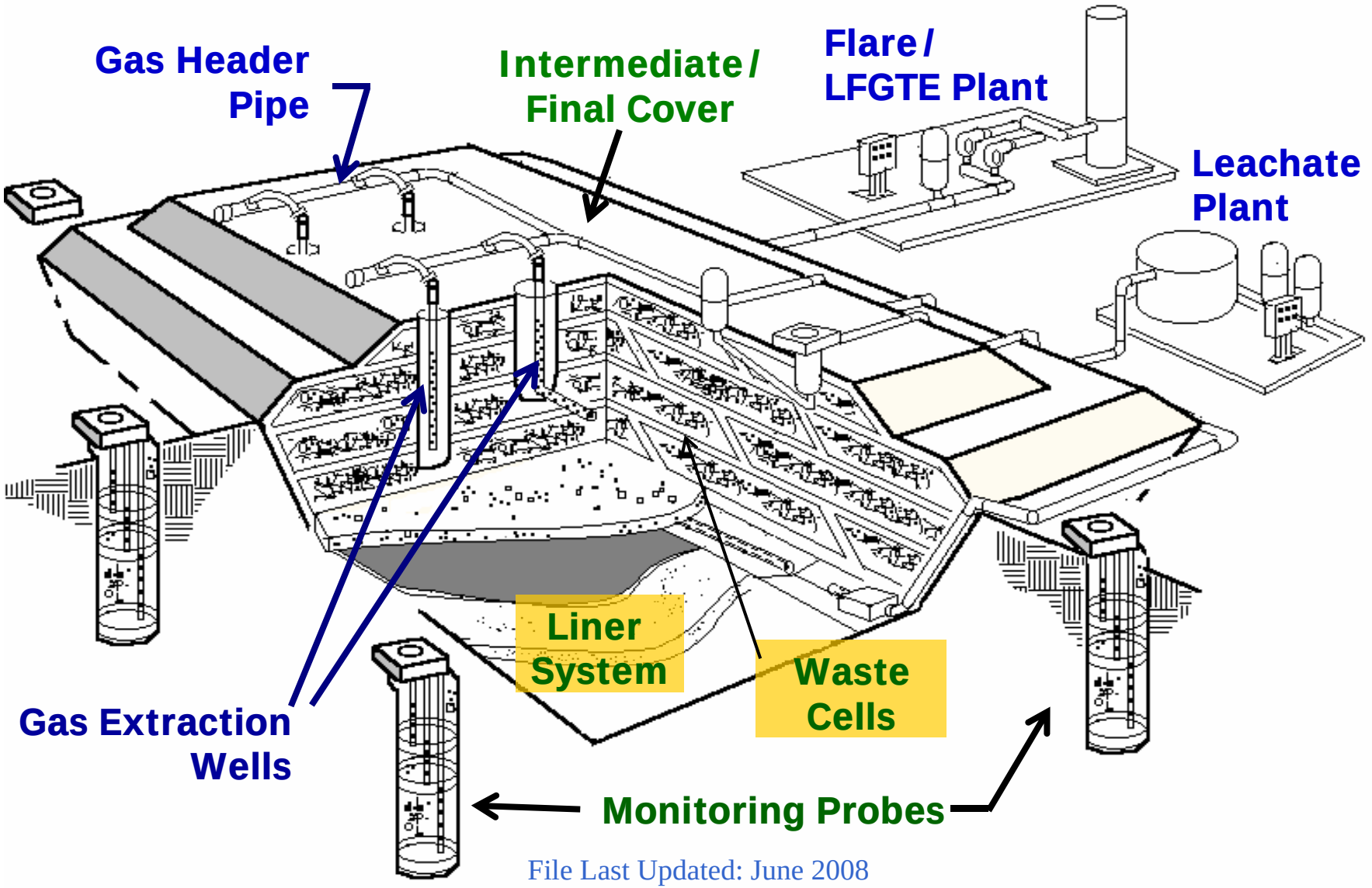
Modern Sanitary Landfill



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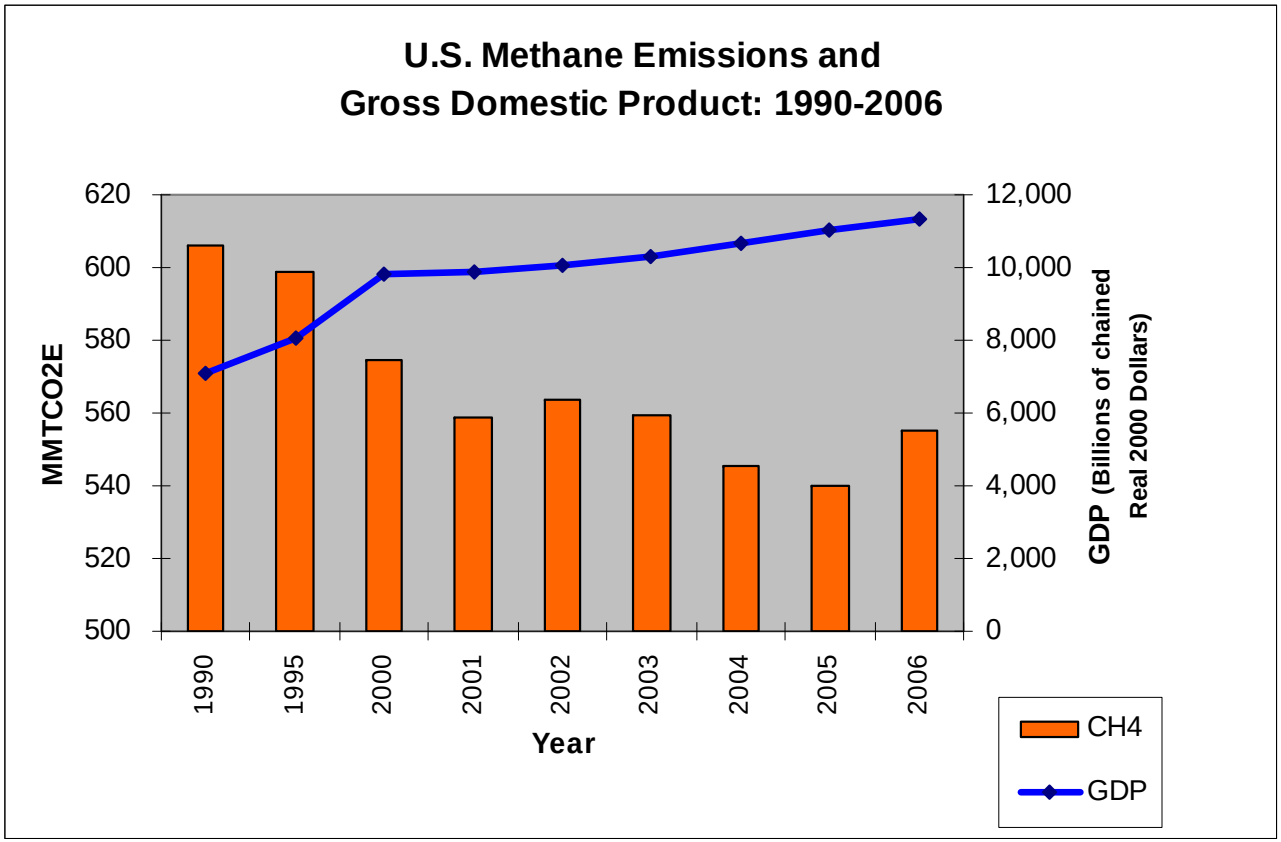
Landfill Gas 101

- Landfill gas (LFG) is a by-product of the decomposition of municipal solid waste (MSW):
  - ~50% methane (CH_4)
  - ~50% carbon dioxide (CO_2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~0.8 megawatts (MW) of electricity
  - ~432,000 cubic feet per day of LFG
- If uncontrolled, LFG contributes to smog and global warming, and may cause health and safety concerns

LANDFILL METHANE OUTREACH PROGRAM

Targeting Methane… Producing Measurable Results

Since 1990, U.S. methane emissions have decreased by over 8% while GDP increased by nearly 60%



Sources: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, U.S. EPA, April 2008; DOC/Bureau of Economic Analysis. Interactive National Income and Product Accounts Table. Last revised on March 27, 2008.

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LANDFILL METHANE OUTREACH PROGRAM

Landfill Gas and Green Power A Winning Combination

- Dual benefit ➔ destroys methane and other organic compounds in LFG
- Offsets use of nonrenewable resources (coal, oil, gas) reducing emissions of SO_2, NO_X, PM, CO_2
  - LFG is a recognized renewable energy resource (Green-e, EPA Green Power Partnership, 31 states, Sierra Club, NRDC)
  - LFG is generated 24/7 and projects have online reliability over 90%
  - LFG can act as a long-term price and volatility hedge against fossil fuels

LANDFILL METHANE OUTREACH PROGRAM

State of the National LFG Industry (April 2008)

- At least 450 operational projects in 43 states supplying:
  - 11 billion kilowatt hours of electricity and 77 billion cubic feet of LFG to direct-use applications annually
- Estimated **Annual** Environmental Benefits
  - Carbon sequestered annually by **~17,800,000 acres of pine or fir forests**, or
  - CO_2 emissions from ~**182,000,000 barrels of oil consumed**, or
  - Annual greenhouse gas emissions from ~**14,300,000 passenger vehicles**
- Estimated **Annual** Energy Benefit
  - Powering more than **870,000 homes** and heating nearly **534,000 homes**

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Diversity of Project Types
Electricity Generation

Internal Combustion Engine (range from 100 kW to 3 MW)

Gas Turbine (range from 800 kW to 10.5 MW)

Microturbine (range from 30 kW to 250 kW)

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Diversity of Project Types
Direct Use of LFG

- Direct-use projects are growing!
  - Boiler applications – replace natural gas, coal, fuel oil
  - Combined heat & power (CHP)
  - Direct thermal (dryers, kilns)
  - Natural gas pipeline injection
    - Medium & high Btu
  - Greenhouse
  - Leachate evaporation
  - Vehicle fuel (LNG, CNG)
  - Artist studio
  - Hydroponics
  - Aquaculture (fish farming)

Greenhouse Burlington, NJ

Pottery Studio Sugar Grove, NC

LFG-fired Boiler Ft. Wayne, IN

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Emerging Technologies: LFG for Vehicle Fuel

- City of Denton, TX uses LFG to fuel a 3 million gal/yr biodiesel production facility
- Los Angeles, CA converts LFG into CNG to fuel landfill equipment (Puente Hills LF)
- Orange Co, CA – 1st commercial LFG-to-LNG facility online Jan. '07 – used in county waste trucks (Frank R. Bowerman LF)
- Central LF, CA plans to convert LFG to CNG to fuel Sonoma County school buses
- Franklin Co, OH is in the process of using LFG to produce methanol as a feedstock for biodiesel
- Waste Management in CA plans to produce 10-20K gal LNG per day for garbage trucks

Regulations that Affect LFGE

- LFGE projects may be affected by a variety of federal, state, and local air quality regulations. Applicable federal Clean Air Act regulations include:
  - New Source Performance Standards (NSPS) / Emission Guidelines (EG)
  - Title V
  - Maximum Achievable Control Technology (MACT)
  - New Source Review (NSR)
  - Prevention of Significant Deterioration (PSD)

LFG and RECs

- Renewable Energy Certificates (RECs)
  - Equivalent to 1 MWh of renewable energy generation
  - From $5 to $50 per MWh (0.5 to 5 cents per kWh)
- Companies looking to reduce their environmental footprint purchase RECs from utilities using LFG
  - DuPont – 170 million kWh from biomass & LFG
  - Pitney Bowes – 10% of electricity from wind & LFG
  - Staples – 46 million kWh/year of RECs, 90% from biomass & LFG

Emissions Trading of LFG

- Chicago Climate Exchange (CCX) is an example of a voluntary GHG reduction and trading program
  - Offers a credit of 18.25 metric tons CO_2 per metric ton of methane combusted
  - Applicable for LFG collection and combustion systems placed into service after 12/31/98
  - Prices range from $1 to $6.50 per metric ton (market factors affect pricing)
  - Only landfills not required by federal law (e.g., NSPS) to combust LFG are eligible
  - Landfill methane emission offsets brochure at www.chicagoclimateexchange.com

Federal Finanical Incentives

- Section 45 Tax Credit
  - Electricity generation – 1.0 cent/kWh
  - Placed in service by 12/31/08
  - 5- or 10-year window for credits depending on placed-in-service date
- Clean Renewable Energy Bonds (CREBs)
  - National allocation of $1.2 billion
  - Current issuance period of 1/1/07 to 12/31/08
  - In 2006, IRS granted issuance of 36 bonds for LFGE projects
- Renewable Energy Production Incentive (REPI)
  - Local/state government or non-profit electric co-op facilities
  - Online by 10/1/16
  - Payment for first 10 years of operation

LANDFILL METHANE OUTREACH PROGRAM

Direct-Use Case Study

Lanchester Landfill
Narvon, PA

- ✓ First LFGE project in PA to serve multiple customers – will eventually provide LFG to 4 direct end users
- ✓ Not regulated by PUC as a public utility!
- ✓ 13-mile pipeline through 75 easements and 35 road crossings

2005 LMOP
Award Winner

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LANDFILL METHANE OUTREACH PROGRAM

Direct-Use Case Study

Lanchester Landfill

Narvon, PA (cont.)

- ✓ Public and Private Partnerships
  - ✓ Granger Energy, Chester County Solid Waste Authority & PA DEP overcame economic & technical difficulties

- ✓ Three end users already using LFG in boilers, thermal oxidizers & ovens
- ✓ LFG fuels transport of itself – self-reliant project
- ✓ Estimated annual savings of $300,000 in avoided electricity costs

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LANDFILL METHANE OUTREACH PROGRAM

Direct-Use Case Study

City of Denton Landfill, TX and Biodiesel Industries

- One renewable fuel ‘fuels’ another…
- LFG from city landfill used in industrial process to convert renewable feedstock, vegetable oils, and animal fats into 3 million gal/yr of biodiesel
- City garbage trucks and other utility vehicles are fueled by 80% diesel / 20% biodiesel (B20)
  - Improves regional air quality
  - Stimulates local economic development
  - Reduces dependence on foreign oil

2005 LMOP Award Winner

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LANDFILL METHANE OUTREACH PROGRAM

CHP and Direct-Use Case Study

BMW Manufacturing Greer, SC

LMOP 2003 *Project of the Year*

- 9.5-mile pipeline from Palmetto Landfill to BMW
- 2003 – 4 KG2 gas turbines retrofitted to burn LFG
  - 4.8 MW of electricity generated and 72 million Btu/hr of heat recovered
- 2006 – Converted paint shop to utilize LFG in oven burners and for indirect heating
- LFG accounts for nearly 70% of BMW's energy needs
- BMW saves at least $1 million/yr

LMOP 2006 *Energy End User Partner of the Year*

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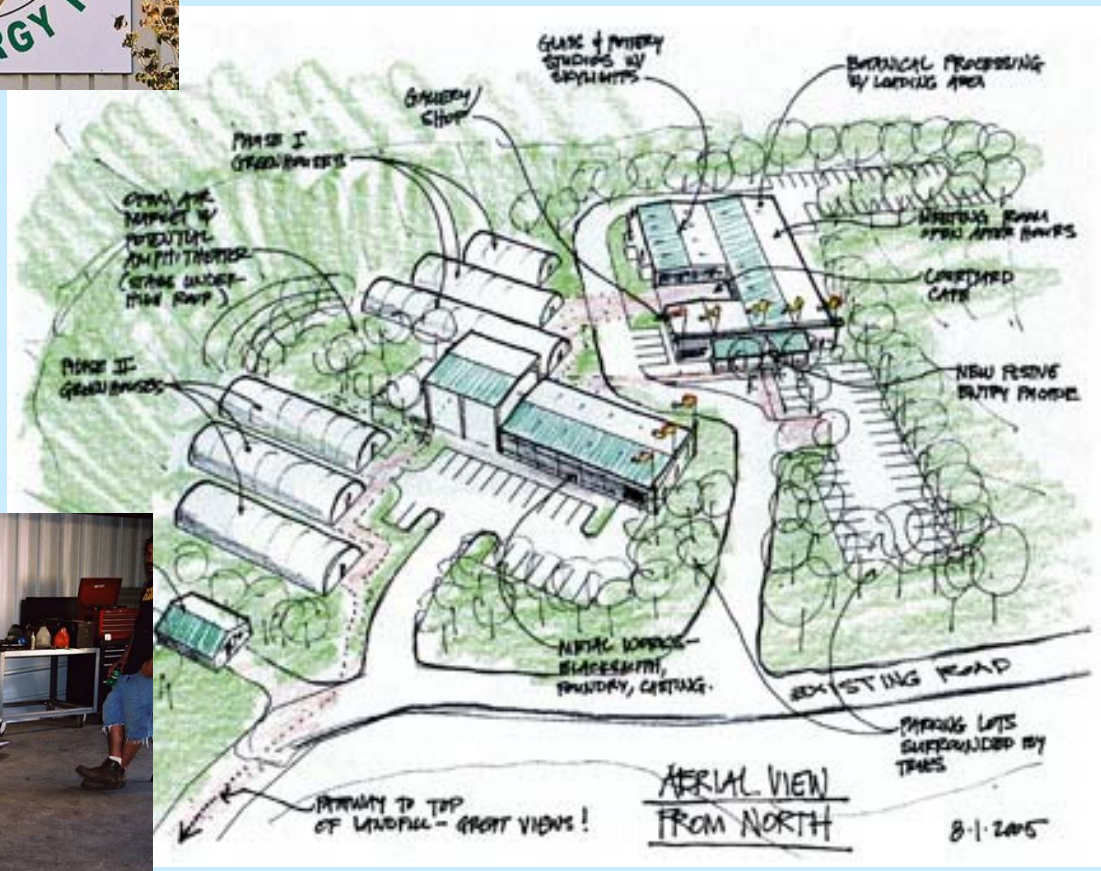
LANDFILL METHANE OUTREACH PROGRAM

Direct-Use Case Study

Jackson County Green Energy Park

Sylva, NC

LMOP 2006 *Project of the Year*



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LANDFILL METHANE OUTREACH PROGRAM

LMOP 2007 *Energy Partners of the Year*

Electricity Case Study

Alameda Power & Telecom and City of Palo Alto, CA

- Two community-based utilities teamed up to meet renewable energy goals
- Alameda – currently 80% renewables
- Palo Alto goal – 10% of electric load from new renewables by 2008; 20% by 2015

- Buena Vista (3.2 MW) online in '06
- Ox Mountain (11.4 MW) and Keller Canyon (4 MW) to be online in '08

= Total of 18.6 MW by end of 2008

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LANDFILL METHANE OUTREACH PROGRAM

High Btu Case Study

Veolia ES Greentree LF Kersey, PA

- Largest designed high Btu LFGE project in U.S. – can process 15.12 mmscfd LFG
- Cleaning: membrane technology, pressure swing absorption, carbon pretreatment, & H_2S removal
- 7-mile pipeline to combined cycle equipment

- Volume of LFG flared reduced by >90%
- Expect ~2 billion cf/yr product quality gas (<1% CO_2)
- Electricity
- RECs

LMOP 2007 Project of the Year

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LANDFILL METHANE OUTREACH PROGRAM

Many Untapped LFG Resources

- Currently ~540 candidate landfills with a total gas generation potential of 240 billion cubic feet per year (~14,000 MMBtu/hr) OR electric potential of 1,280 MW (~10 million MWh/yr)
- If projects were developed at all these landfills, estimated
  - **Annual** Environmental Benefit =

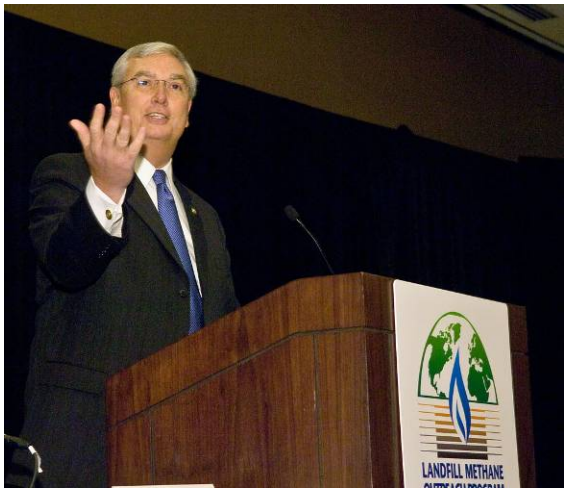
    Carbon sequestered annually by ~12.4 million acres of pine or fir forests OR annual greenhouse gas emissions from ~9.9 million passenger vehicles, AND
  - **Annual** Energy Benefit =

    Powering 808,000 homes OR heating 1.5 million homes per year

LANDFILL METHANE OUTREACH PROGRAM

LMOP Tools and Services

- Network of 700+ Partners (and growing)
- Newsletter and listserv
- Direct project assistance
- Technical and outreach publications
- Project and candidate landfill database
- Web site (epa.gov/lmop)
- Support for ribbon cuttings/ other PR
- Presentations at conferences
- State training workshops
- *Annual LMOP Conference, Project Expo & Partner Awards*



EPA Administrator
Stephen L. Johnson

Keynote Speaker
11th Annual LMOP Conference
Washington, DC

January 9, 2008

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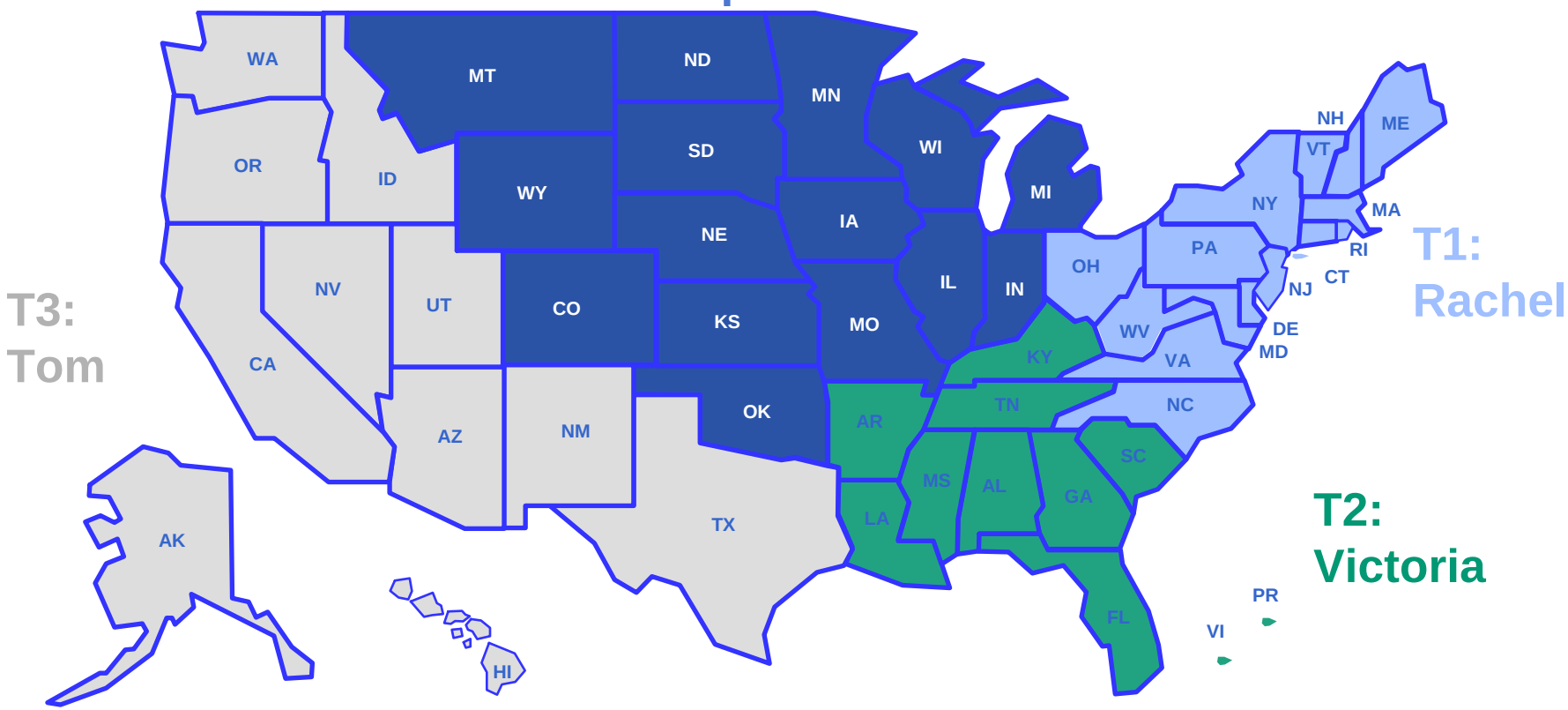
How Can We Work Together? Direct Project Assistance

- Analyze landfill resource – gas modeling
- Identify potential matches – *LMOP Locator*
- Assess landfill and end user facilities
- Look at project possibilities
  - Direct-use (boiler, heating, cooling, direct thermal)
  - Combined Heat & Power (engine, turbine, microturbine)
  - Electric (engine, turbine, microturbine)
  - Alternative Fuels (medium or high Btu, LNG, CNG)
- Initial feasibility analyses – *LFGcost*

For More Information

www.epa.gov/lmop



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